Appendix I-E

Human Health Risk

Appendix I-E
Human Health Risk

Whereas Section 5.2 presents the methodology and key results of the screening assessment of risk to human health, this appendix provides the details of the input and output of the assessment.

Much of the information in this appendix is provided on diskette. Several of the files on diskette are very large. To make them available, they have been compressed with the commercial compression routine PKZIP (PKWARE 1992). "Exe" as the extension of the file name indicates those files that have been compressed and are capable of decompressing themselves. When these files are decompressed, they will automatically reestablish the computer code and necessary input files. The files provided, if all decompressed, will require a total of over 140 megabytes of hard disk storage. The reader is cautioned to have ample disk storage available.

To decompress an "exe" file:

- Create a directory on your hard drive and copy the "exe" files into it from the diskette.
- To decompress the files:
  - In DOS, while in the directory you created, type the "exe" file name and hit enter.
  - In Microsoft Windows File Manager, double click on each "exe" file and it will decompress. To view the decompressed file names in File Manager, click on REFRESH under WINDOW.
  - In Microsoft Windows 95, click on START, then RUN, then BROWSE; indicate directory you have created; double click on each "exe" file to decompress it.
- To view the individual files, open the files in any text processing software or spreadsheet.

Computer Code and Parameters of Calculations

A computer code, HUMAN, implemented the equations of Section 5.2.1. The HUMAN code was developed under quality assurance controls. Documentation of the code requirements, development specifications, development testing, and user's manual are available in project records. A compressed copy of the HUMAN code in compiled FORTRAN is included on diskette with this report. The compression routine PKZIP2 (PKWare 1992) was used to make self-extracting files. Upon execution, these compressed files uncompress into the full suite of original ASCII or FORTRAN files.

The HUMAN code used as input the media files described in Section 3.0. Compressed copies of the deterministic media files are included on the diskette as well. These files are directly related to the media files described in Section 3.0 and Appendix I-B. The files were converted to a format readable by the HUMAN code. In addition, all of the deterministic and stochastic input files for the scenarios are provided in compressed form. Note that the stochastic media files are too large to put on diskette even when compressed. They may be obtained upon request.

The contents of the diskette are:

Filename:	File description
humancod.exe	Compressed, self-extracting, executable HUMAN code
hh_dt_ex.exe	Compressed, self-extracting, deterministic, external measurements media file used by HUMAN
hh_dt_ss.exe	Compressed, self-extracting, deterministic, environmental media concentrations file used by HUMAN
det_key.exe	Eleven compressed, self-extracting, scenario input files for the HUMAN code for the deterministic calculations
sto_key.exe	Eleven compressed, self-extracting, scenario input files for the HUMAN code for the stochastic calculations

Results of the Calculations

All numerical results of the calculations described in Section 5.2 are provided in this appendix and included on a diskette provided with the report.

Human health risk estimated for each scenario at each location is shown in Figures E.1-E.9. For each scenario, there are three graphics: one depicting the estimate of risk from carcinogenic chemicals, one depicting the hazard index estimated from toxic chemicals, and one depicting the estimate of risk from radionuclides.

Figures E.1-E.9 follow the format described in Section 5.2 for Figures 5.5-5.6. As with the figures in Section 5.2, the absolute values of the risk estimates may be quite high. As described in Section 5.2, the absolute magnitude of the estimated risk is merely indicative of potential areas of concern because the estimates are based on conservative assumptions and do not apply to any real human populations at this time. However, the actual results are provided for those readers wishing to understand the nature of the screening level calculations performed for this assessment. The results of the screening assessment of human risk will be used to support cleanup decisions and to focus a subsequent and more comprehensive risk assessment.

The numerical results of the calculations are provided to the reader on diskette. The diskette contains all of the output from the input files described in the previous section. The calculations run were both deterministic (single valued input and output) and stochastic (parameters varied over their expected ranges).

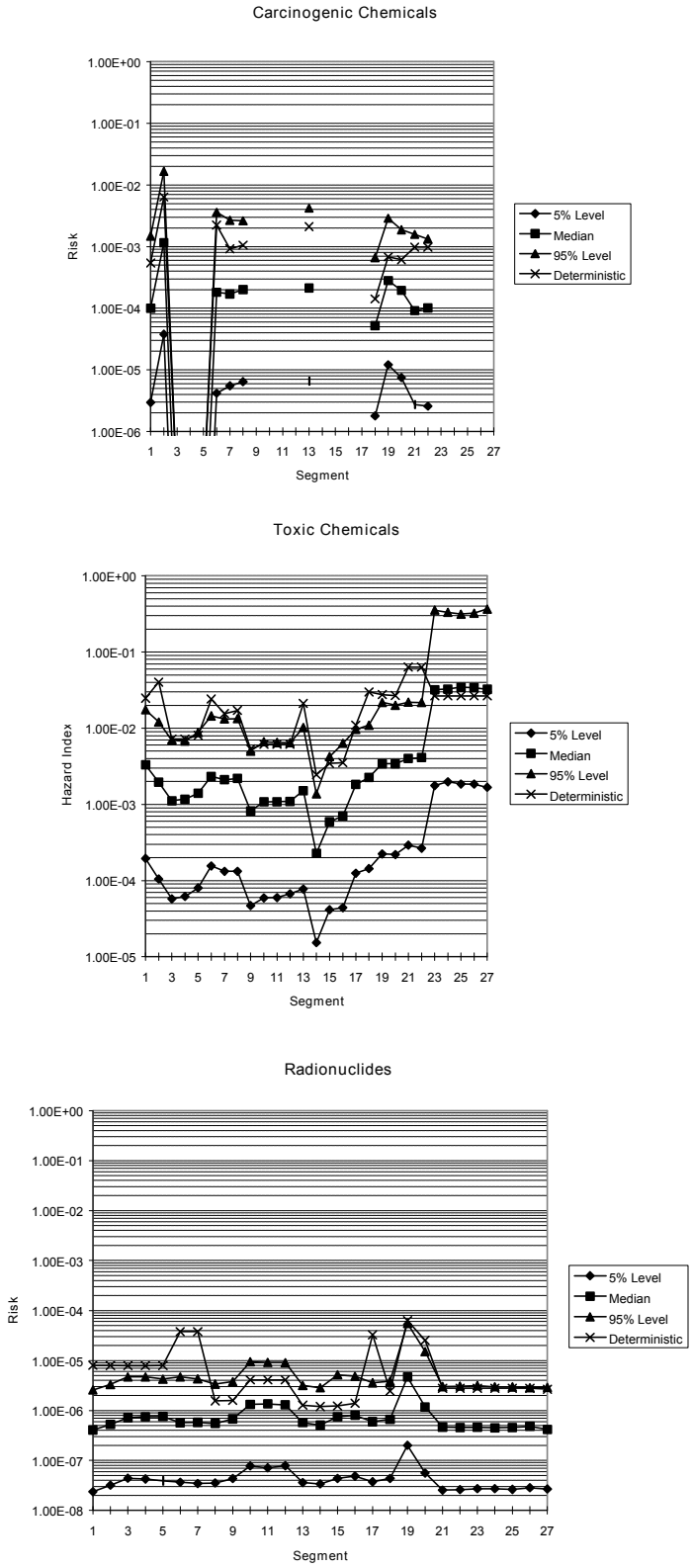


Figure E.1. Human Health Risk Estimate for the Industrial Worker Scenario

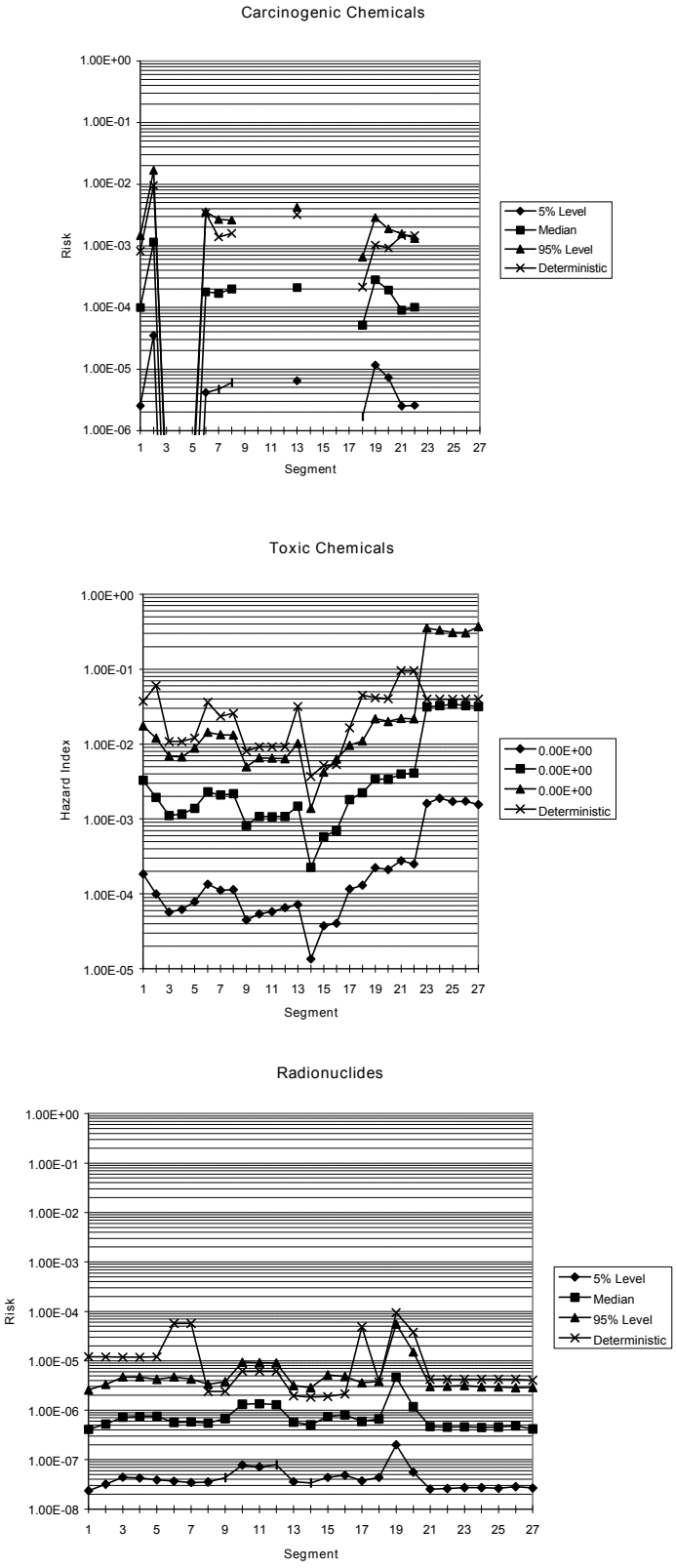


Figure E.2. Human Health Risk Estimate for the Fish Hatchery Worker Scenario

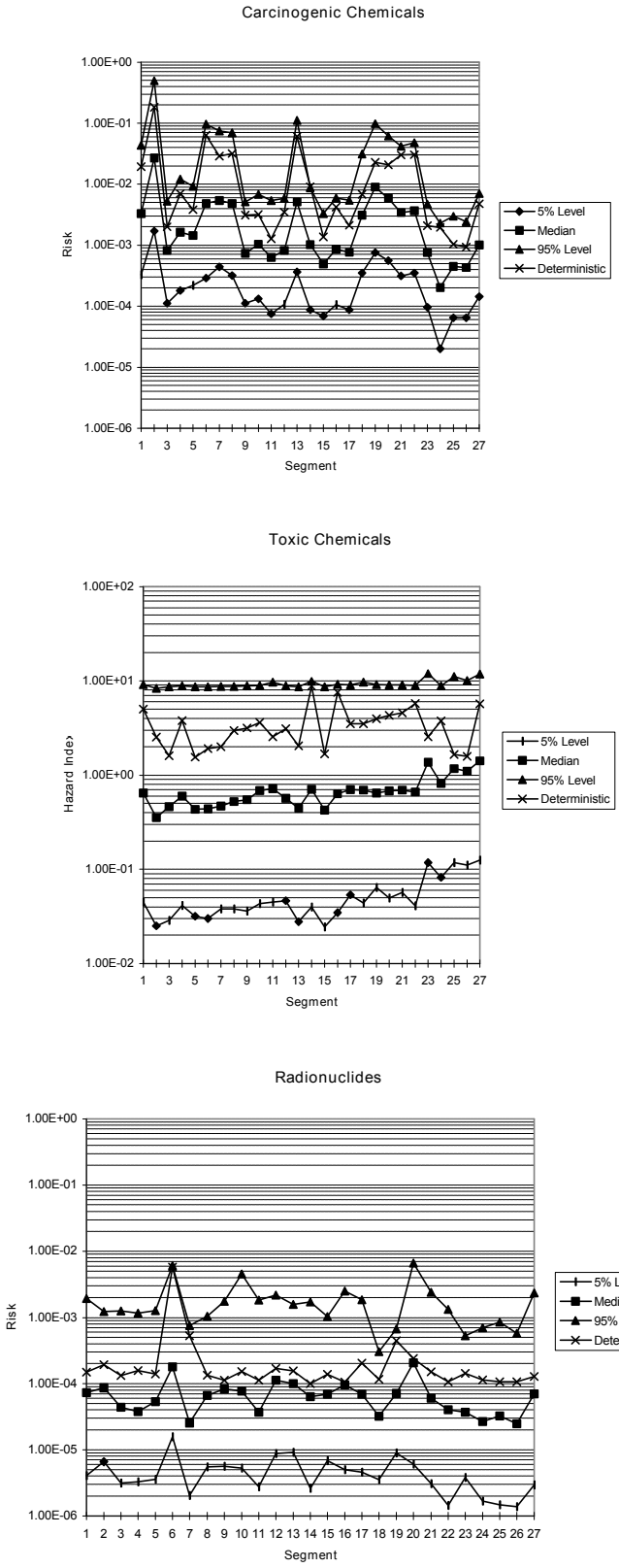


Figure E.3. Human Health Risk Estimate for the Avid Recreational Visitor Scenario

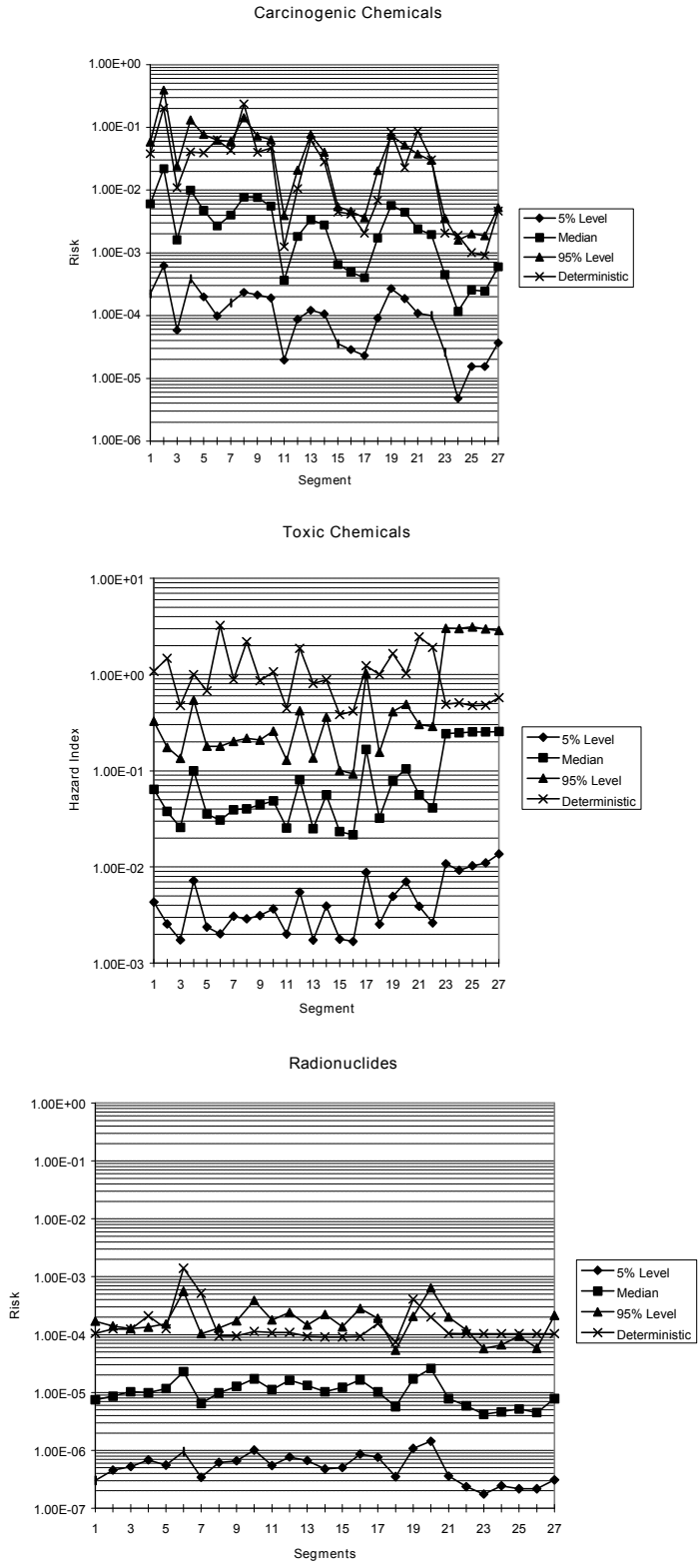


Figure E.4. Human Health Risk Estimate for the Casual Recreational Visitor Scenario

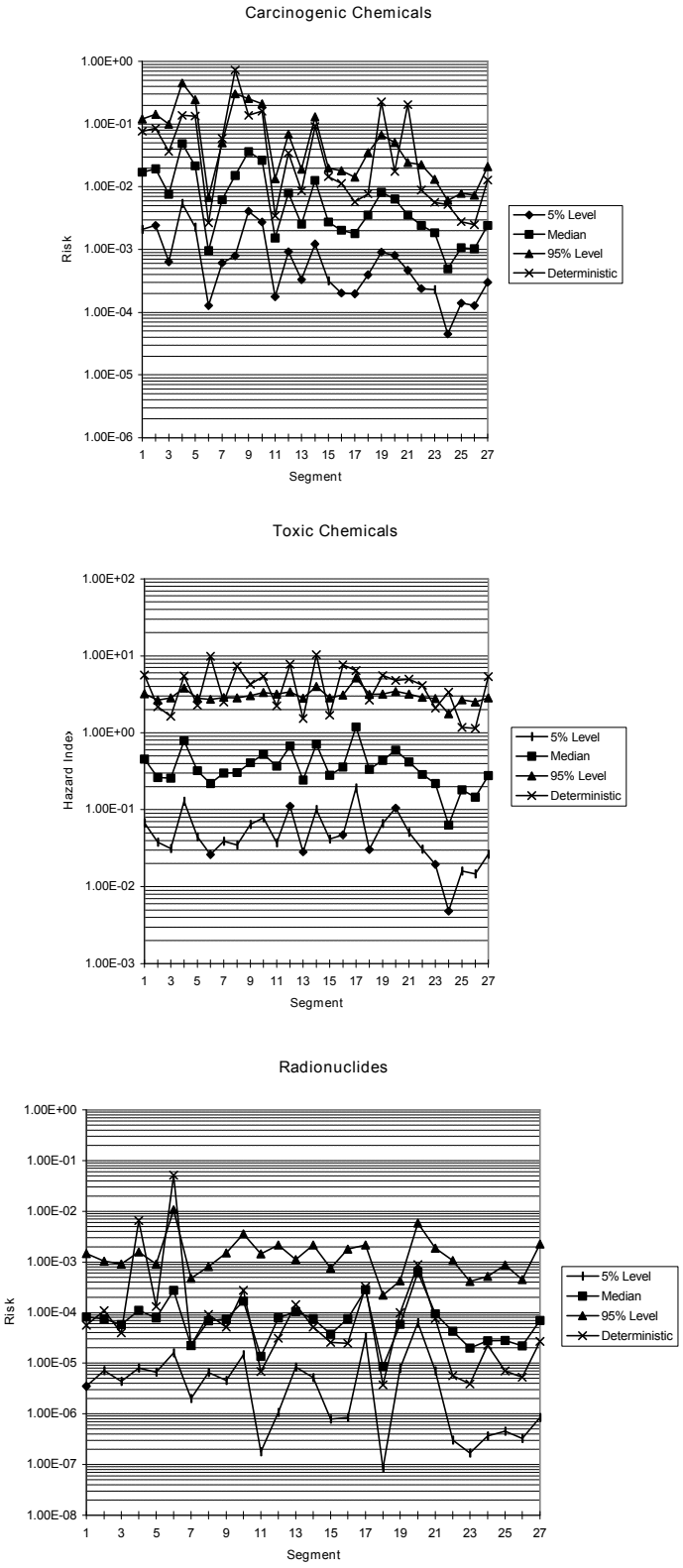


Figure E.5. Human Health Risk Estimate for the Native American Upland Hunter Scenario

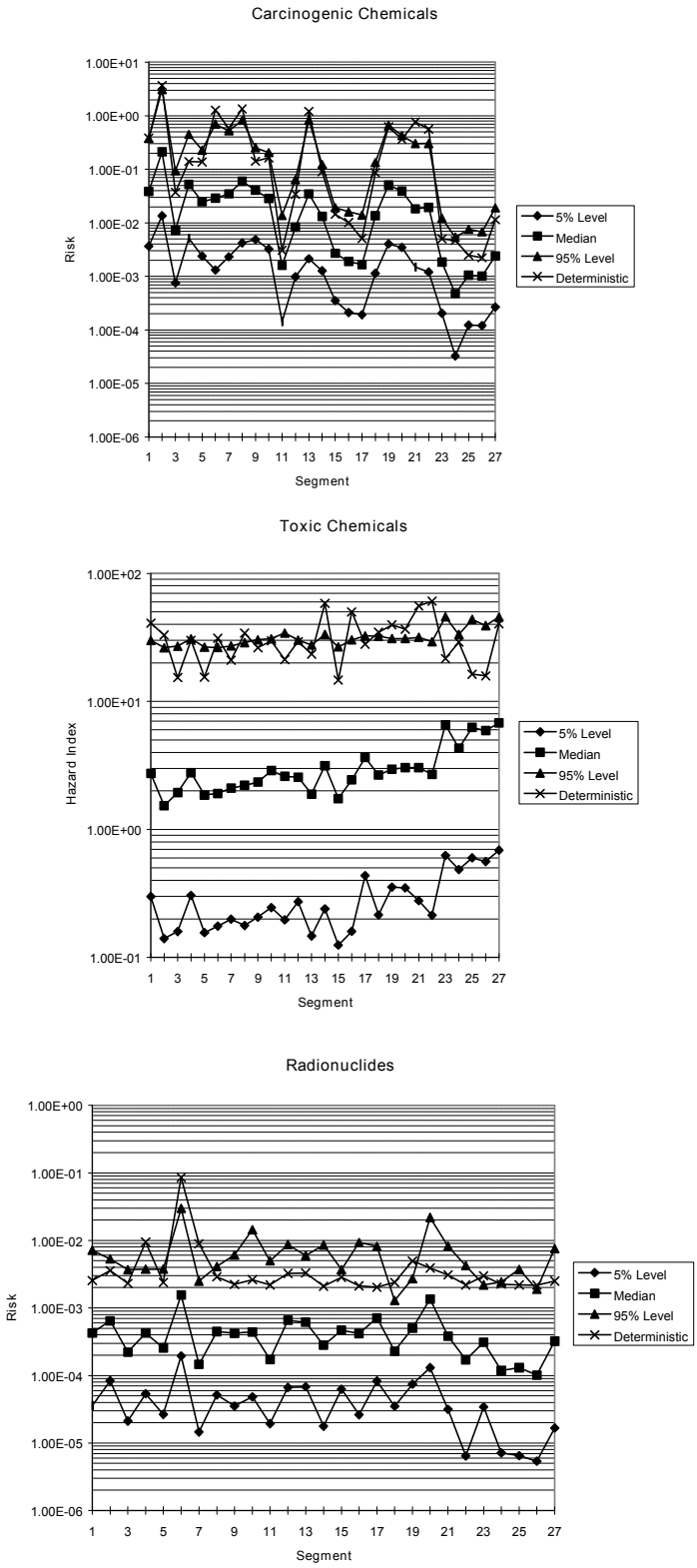


Figure E.6. Human Health Risk Estimate for the Native American River Focused Hunter and Fisher Scenario

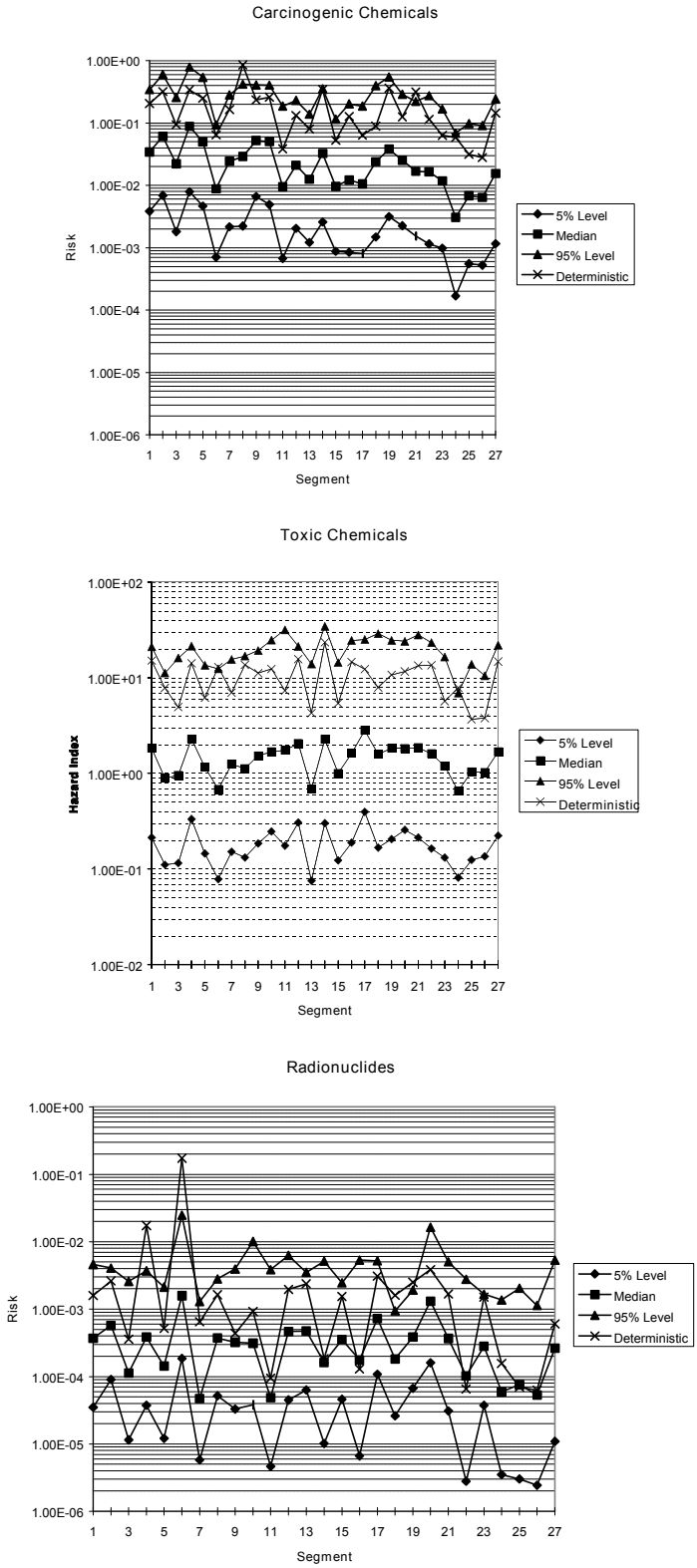


Figure E.7. Human Health Risk Estimate for the Native American Gatherer of Plant Materials Scenario

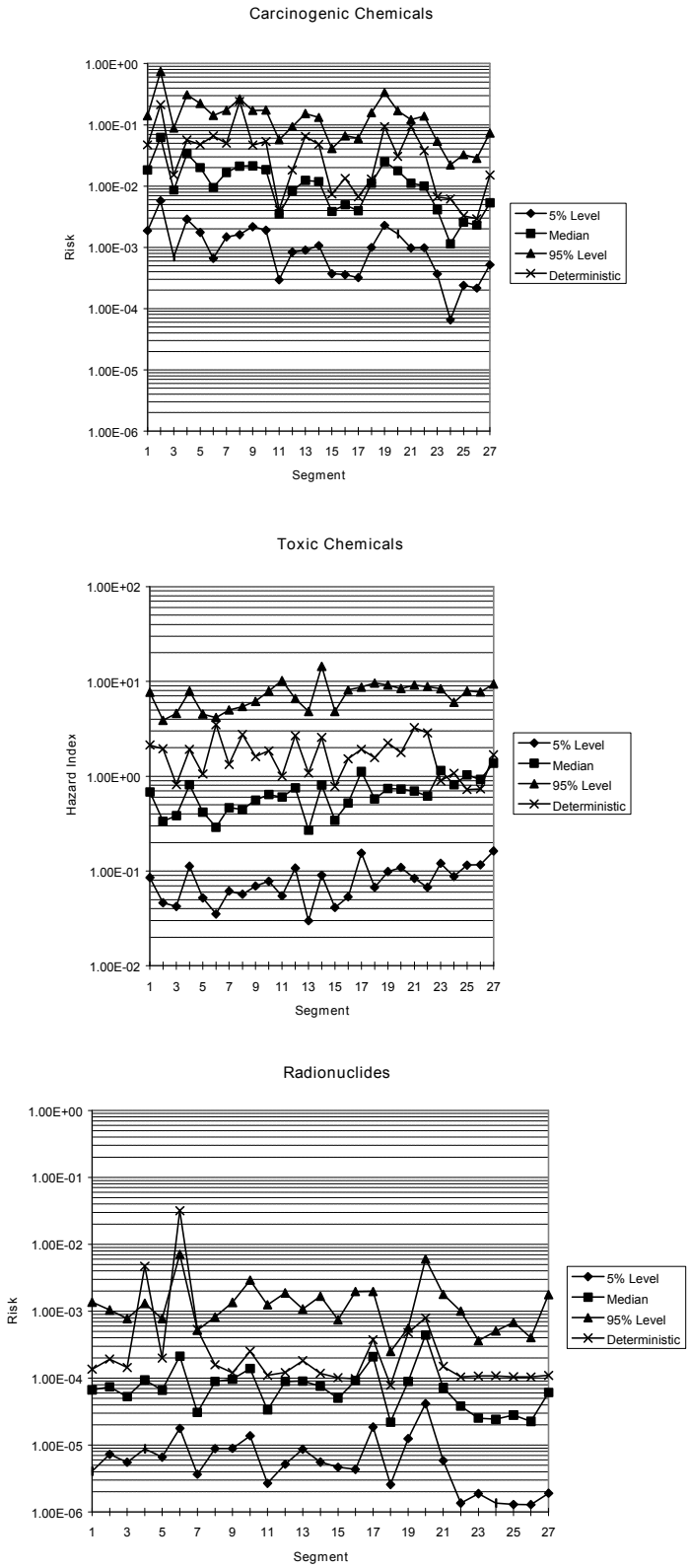


Figure E.8. Human Health Risk Estimate for the Resident Scenario

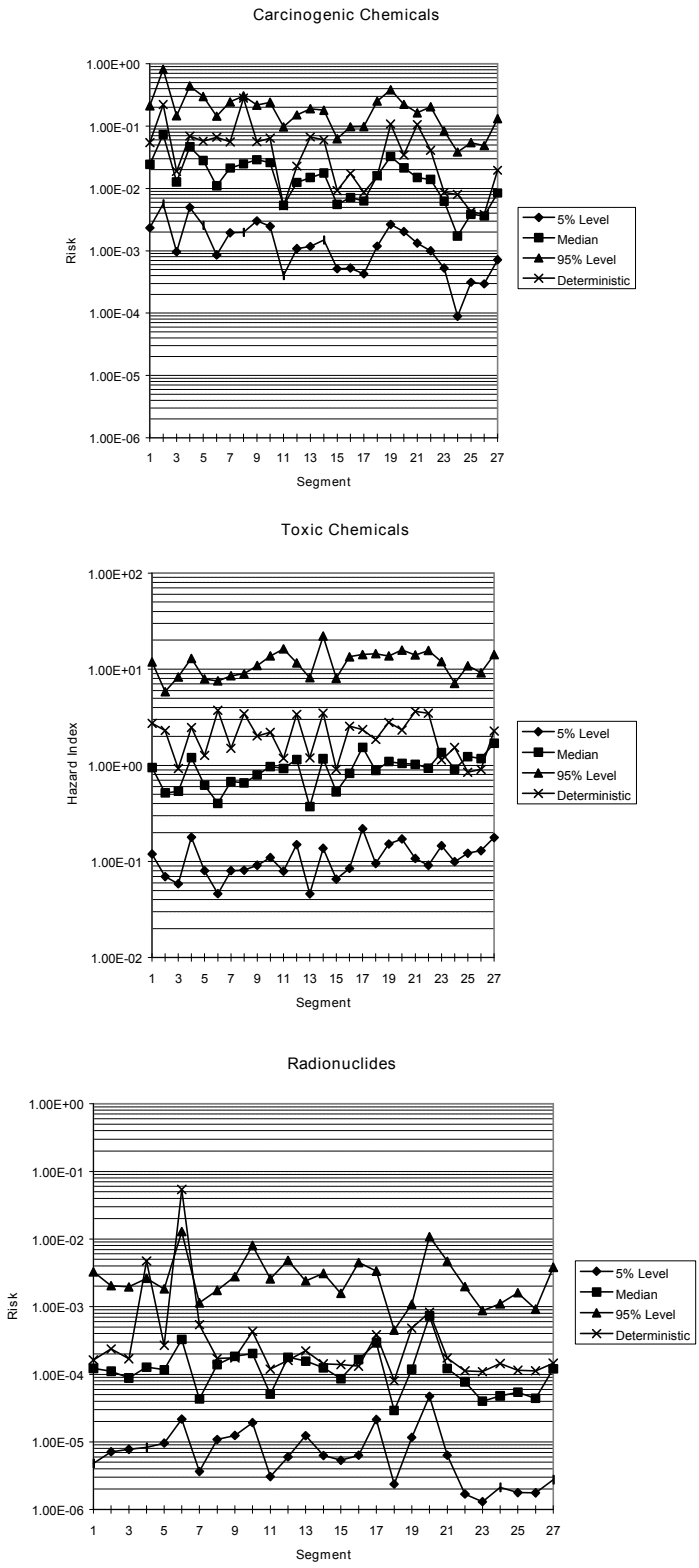


Figure E.9. Human Health Risk Estimate for the Agricultural Resident Scenario

Both sets of results are provided. The results of the deterministic calculations are provided in the self-extracting, compressed file "determ.exe." Additional details for each of these cases are provided in the self-extracting, compressed file, "det_dtl.exe." The results of the stochastic calculations are provided in self-extracting, compressed file, "stochast.exe." Additional details for each of these cases are provided in the self-extracting, compressed file, "stoc_dtl.exe." The values found in these various files were used to make the summary spreadsheet, "results.xls."

The contents of the diskette are:

Filename:	File description
determ.exe	Compressed, self-extracting file containing all of the calculational results of the HUMAN code runs for the deterministic simulations
det_dtl.exe	Compressed, self-extracting file containing secondary output from the deterministic runs, providing additional detail on the pathways and sources of exposure for each location and for each contaminant
stochast.exe	Compressed, self-extracting file containing all of the calculational results of the HUMAN code runs for the stochastic simulations
stoc_dtl.exe	Compressed, self-extracting file containing secondary output from the stochastic runs, providing additional detail on the pathways and sources of exposure for each location and for each contaminant
results.xls	Microsoft Excel 5.0 file of the numerical results as well as the graphical displays of those results (Figures E.1-E.9) by scenario

Computer Code for the Statistical Analysis of Downstream/Upstream Comparisons and the Results

As described in Section 5.2, the human risk results at Hanford-influenced locations were compared with those estimated for an upstream and, therefore, presumably minimally contaminated location (Segment 1). Graphical summaries of the results of the statistical evaluation are provided in Section 5.2.4 (Figures 5.36 and 5.37) for the Ranger and Native American Subsistence Resident scenarios, respectively. Summaries for the other scenarios (Figures E.10-E.18) are provided here.

Because the distributions hold more information than can be easily used, means of comparing the entire upstream and downstream distributions were developed. These techniques were based on detailed statistical approaches called the Mann-Whitney U Test and the Kruskal-Wallis One-Way Anova Test (Gibbons 1971).

A computer code to implement the Kruskal-Wallis and Mann-Whitney statistical tests (RISKS) was prepared. The RISKS code was developed under quality assurance controls. Documentation of the code

Figure E.10. Statistical Evaluation of the Differences Between a Segment Not Affected by Hanford Site Operations and Downstream Segments Affected by Hanford Site Operations for the Industrial Worker Scenario

Figure E.10. Industrial Worker

Background

Above background, insignificantly

Above threshold of 1E-6 for lifetime risk or 0.01 for hazard index

Above threshold of 1E-4 for lifetime risk or 1.0 for hazard index

Based on stochastic output of Industrial Worker Scenario

Results identified using "RISKS" program, implementing Kruskal-Wallis Test (2-sided) and Mann-Whitney U Test (1-sided) (Gibbons 1971)

The statistical tests use a tail probability of 5%, yielding a 1-in-20 chance of false positives

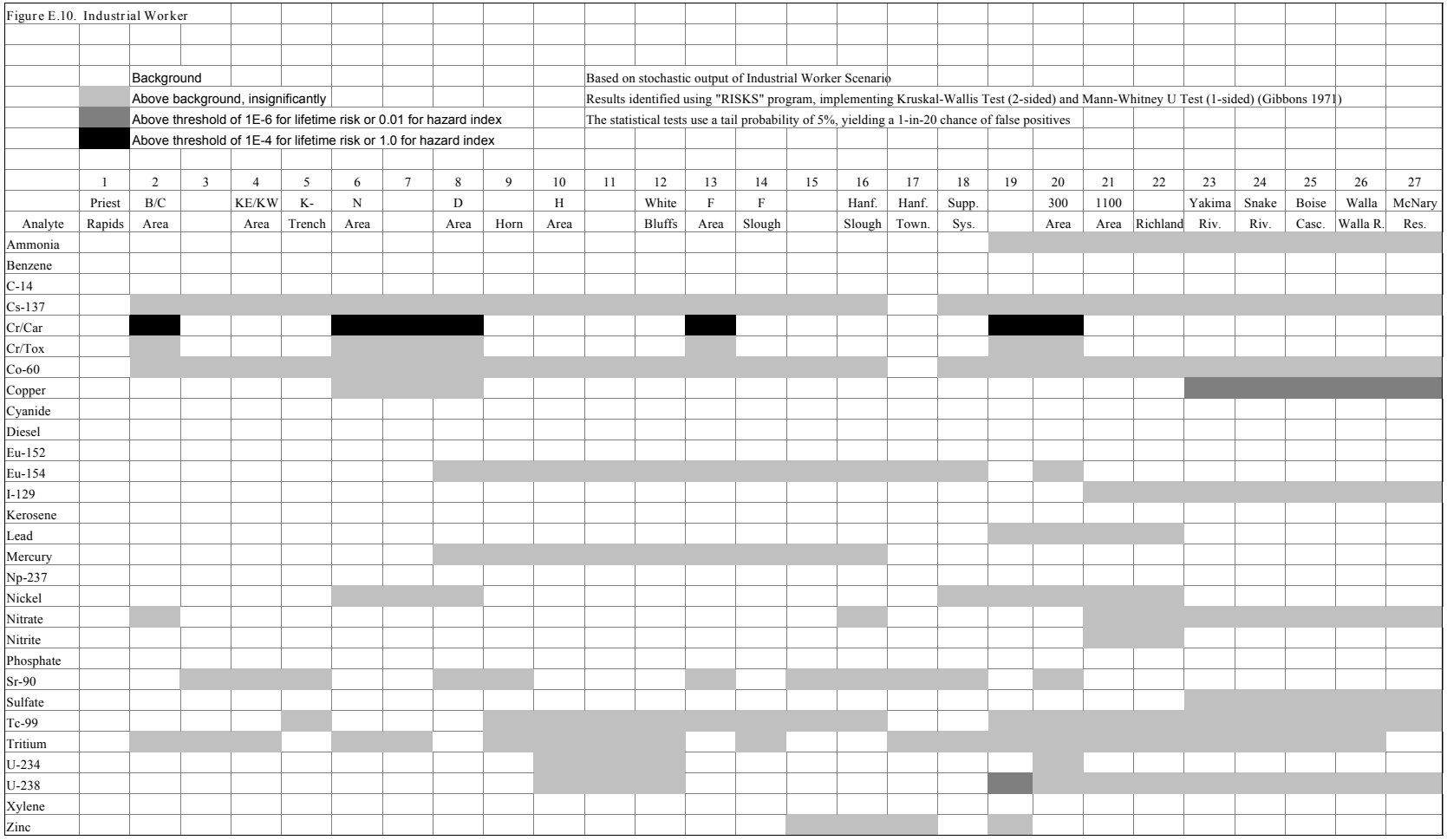


Figure E.11. Statistical Evaluation of the Differences Between a Segment Not Affected by Hanford Site Operations and Downstream Segments Affected by Hanford Site Operations for the Fish Hatchery Worker Scenario


Background
Above background, insignificantly
Above threshold of 1E-6 for lifetime risk or 0.01 for hazard index
Above threshold of 1E-4 for lifetime risk or 1.0 for hazard index
Based on stochastic output of Fish Hatchery Worker Scenario
Results identified using "RISKS" program, implementing Kruskal-Wallis Test (2-sided) and Mann-Whitney U Test (1-sided) (Gibbons 1971)
The statistical tests use a tail probability of 5%, yielding a 1-in-20 chance of false positives
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Priest Rapids
B/C Area
KE/KW Area
K- Trench
N Area
D Area
Horn
H Area
White Bluffs
F Area
F Slough
Hanf. Slough
Hanf. Town.
Supp. Sys.
300 Area
1100 Area
Richland
Yakima Riv.
Snake Riv.
Boise Casc.
Walla Walla R.
McNary Res.
Analyte
Ammonia
Benzene
C-14
Cs-137
Cr/Car
Cr/Tox
Co-60
Copper
Cyanide
Diesel
Eu-152
Eu-154
I-129
Kerosene
Lead
Mercury
Np-237
Nickel
Nitrate
Nitrite
Phosphate
Sr-90
Sulfate
Tc-99
Tritium
U-234
U-238
Xylene
Zinc

Figure E.12. Statistical Evaluation of the Differences Between a Segment Not Affected by Hanford Site Operations and Downstream Segments Affected by Hanford Site Operations for the Avid Recreational Visitor Scenario

Figure E.12. Avid Recreational Visitor

Background

Above background, insignificantly

Above threshold of 1E-6 for lifetime risk or 0.01 for hazard index

Above threshold of 1E-4 for lifetime risk or 1.0 for hazard index

Based on stochastic output of Avid Recreational Visitor Scenario

Results identified using "RISKS" program, implementing Kruskal-Wallis Test (2-sided) and Mann-Whitney U Test (1-sided) (Gibbons 1971)

The statistical tests use a tail probability of 5%, yielding a 1-in-20 chance of false positives

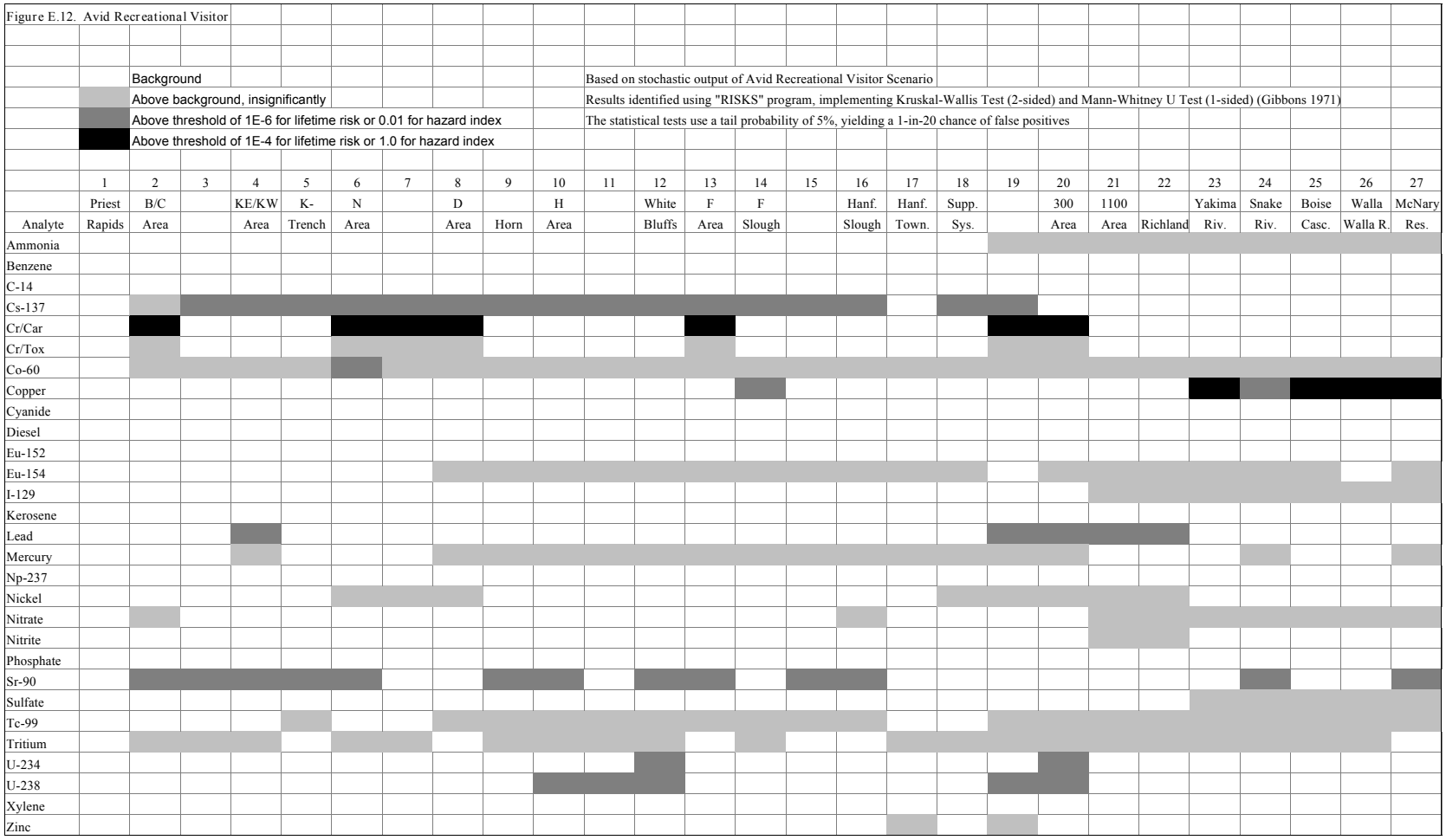


Figure E.13. Statistical Evaluation of the Differences Between a Segment Not Affected by Hanford Site Operations and Downstream Segments Affected by Hanford Site Operations for the Casual Recreational Visitor Scenario

		Background									Based on stochastic output of Casual Recreational Visitor Scenario																		
		Above background, insignificantly									Results identified using "RISKS" program, implementing Kruskal-Wallis Test (2-sided) and Mann-Whitney U Test (1-sided) (Gibbons 1971)																		
		Above threshold of 1E-6 for lifetime risk or 0.01 for hazard index									The statistical tests use a tail probability of 5%, yielding a 1-in-20 chance of false positives																		
		Above threshold of 1E-4 for lifetime risk or 1.0 for hazard index																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		
	Priest	B/C		KE/KW	K-	N		D		H		White	F	F		Hanf.	Hanf.	Supp.		300	1100		Yakima	Snake	Boise	Walla	McNary		
Analyte	Rapids	Area		Area	Trench	Area		Area	Horn	Area		Bluffs	Area	Slough		Slough	Town.	Sys.		Area	Area	Richland	Riv.	Riv.	Casc.	Walla R.	Res.		
Ammonia																													
Benzene																													
C-14																													
Cs-137																													
Cr/Car																													
Cr/Tox																													
Co-60																													
Copper																													
Cyanide																													
Diesel																													
Eu-152																													
Eu-154																													
I-129																													
Kerosene																													
Lead																													
Mercury																													
Np-237																													
Nickel																													
Nitrate																													
Nitrite																													
Phosphate																													
Sr-90																													
Sulfate																													
Tc-99																													
Tritium																													
U-234																													
U-238																													
Xylene																													
Zinc																													

Figure E.14. Statistical Evaluation of the Differences Between a Segment Not Affected by Hanford Site Operations and Downstream Segments Affected by Hanford Site Operations for the Native American Upland Hunter Scenario

Figure E.14. Native American Upland Hunter

Background

Above background, insignificantly

Above threshold of 1E-6 for lifetime risk or 0.01 for hazard index

Above threshold of 1E-4 for lifetime risk or 1.0 for hazard index

Based on stochastic output of Native American Upland Hunter Scenario

Results identified using "RISKS" program, implementing Kruskal-Wallis Test (2-sided) and Mann-Whitney U Test (1-sided) (Gibbons 1971)

The statistical tests use a tail probability of 5%, yielding a 1-in-20 chance of false positives

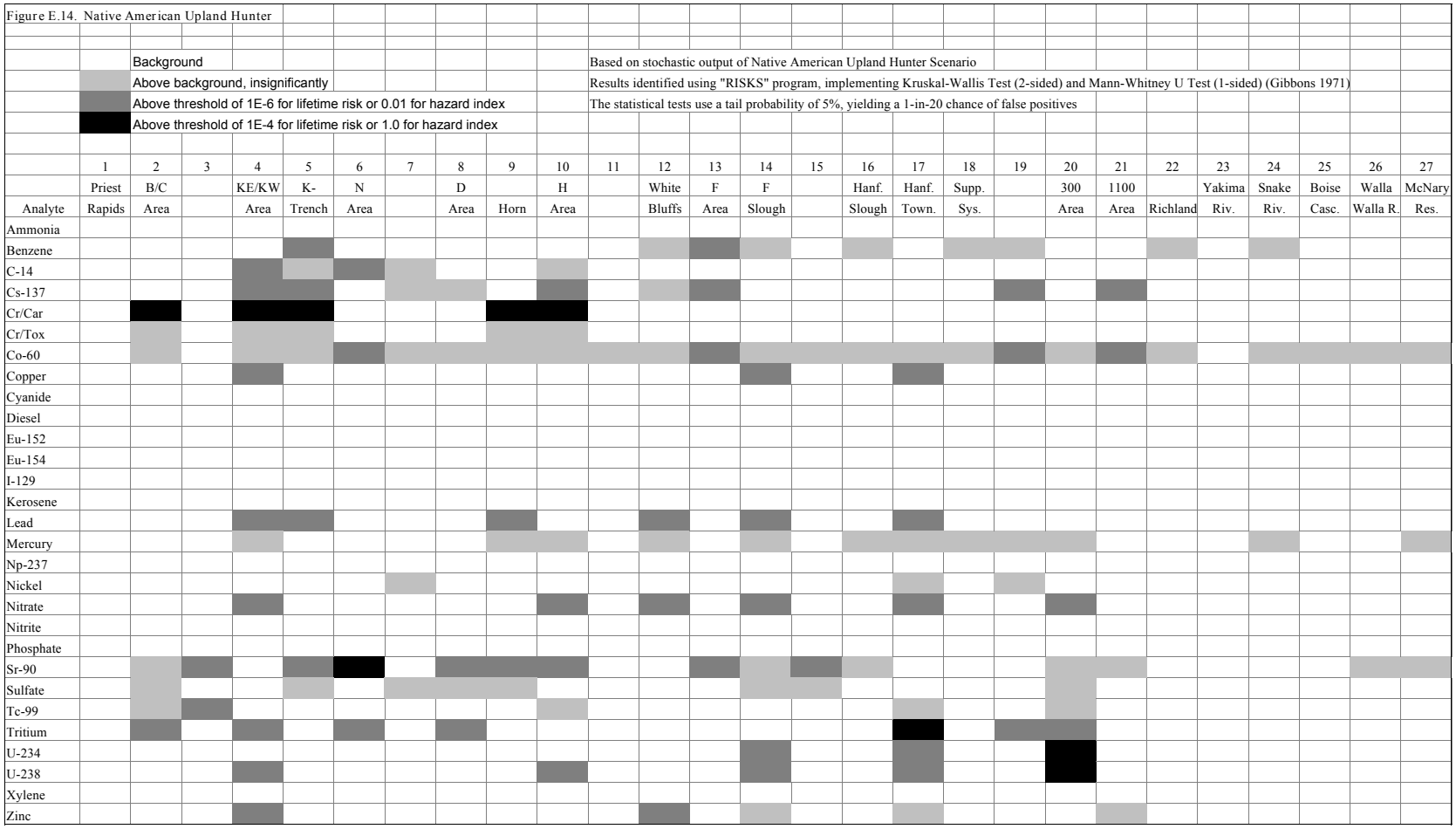


Figure E.15. Statistical Evaluation of the Differences Between a Segment Not Affected by Hanford Site Operations and Downstream Segments Affected by Hanford Site Operations for the Native American Hunter/Fisher Scenario

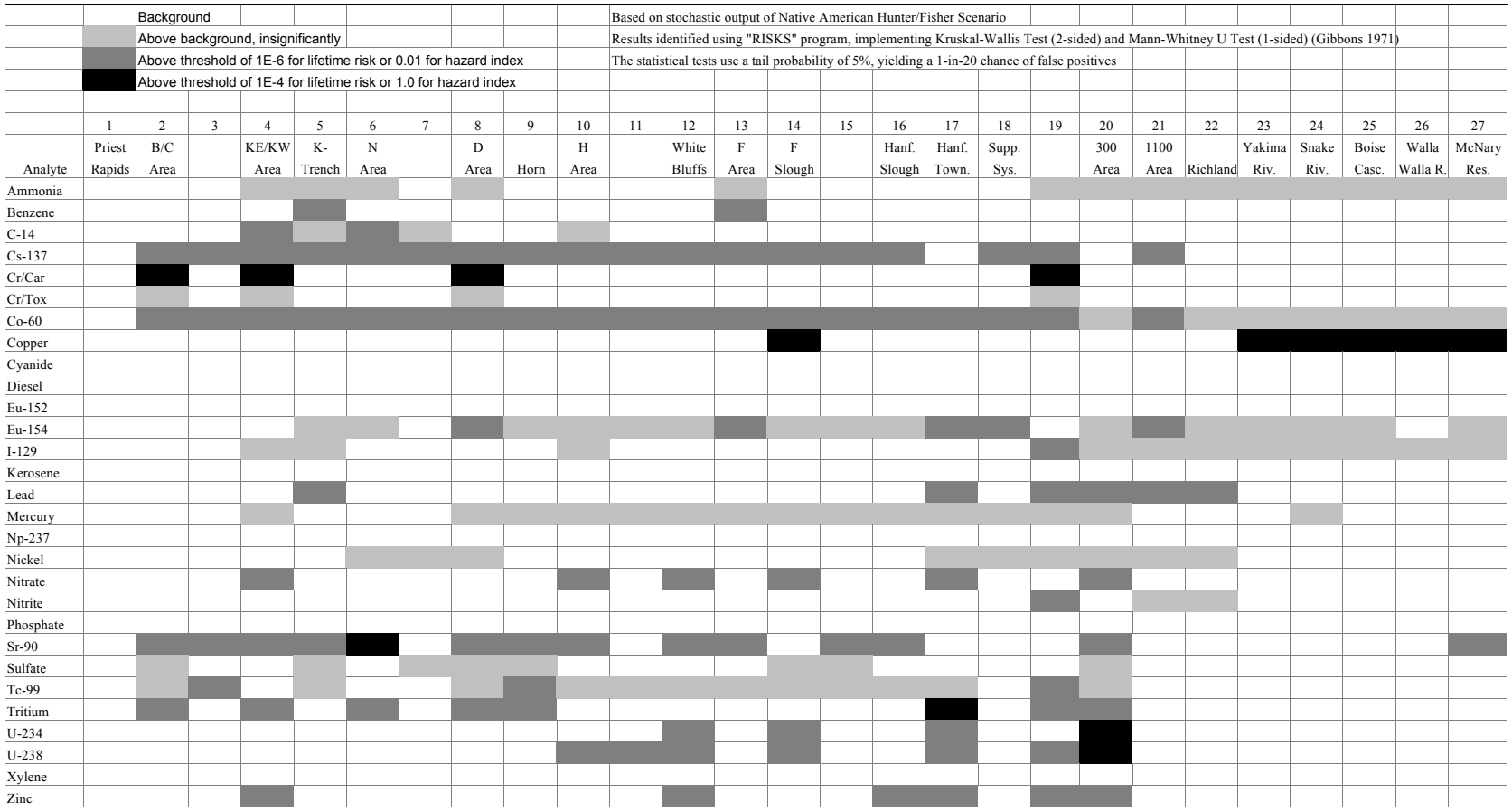

Background
Above background, insignificantly
Above threshold of 1E-6 for lifetime risk or 0.01 for hazard index
Above threshold of 1E-4 for lifetime risk or 1.0 for hazard index
Based on stochastic output of Native American Hunter/Fisher Scenario
Results identified using "RISKS" program, implementing Kruskal-Wallis Test (2-sided) and Mann-Whitney U Test (1-sided) (Gibbons 1971)
The statistical tests use a tail probability of 5%, yielding a 1-in-20 chance of false positives
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Priest B/C KE/KW K- N D H White F F Hanf. Hanf. Supp. 300 1100 Yakima Snake Boise Walla McNary
Rapids Area Area Trench Area Area Horn Area Bluffs Area Slough Slough Town. Sys. Area Area Richland Riv. Riv. Casc. Walla R. Res.
Ammonia
Benzene
C-14
Cs-137
Cr/Car
Cr/Tox
Co-60
Copper
Cyanide
Diesel
Eu-152
Eu-154
I-129
Kerosene
Lead
Mercury
Np-237
Nickel
Nitrate
Nitrite
Phosphate
Sr-90
Sulfate
Tc-99
Tritium
U-234
U-238
Xylene
Zinc

Figure E.16. Statistical Evaluation of the Differences Between a Segment Not Affected by Hanford Site Operations and Downstream Segments Affected by Hanford Site Operations for the Native American Gatherer Scenario

Figure E.16. Native American Gatherer

Background

Above background, insignificantly

Above threshold of 1E-6 for lifetime risk or 0.01 for hazard index

Above threshold of 1E-4 for lifetime risk or 1.0 for hazard index

Based on stochastic output of Native American Gatherer Scenario

Results identified using "RISKS" program, implementing Kruskal-Wallis Test (2-sided) and Mann-Whitney U Test (1-sided) (Gibbons 1971)

The statistical tests use a tail probability of 5%, yielding a 1-in-20 chance of false positives

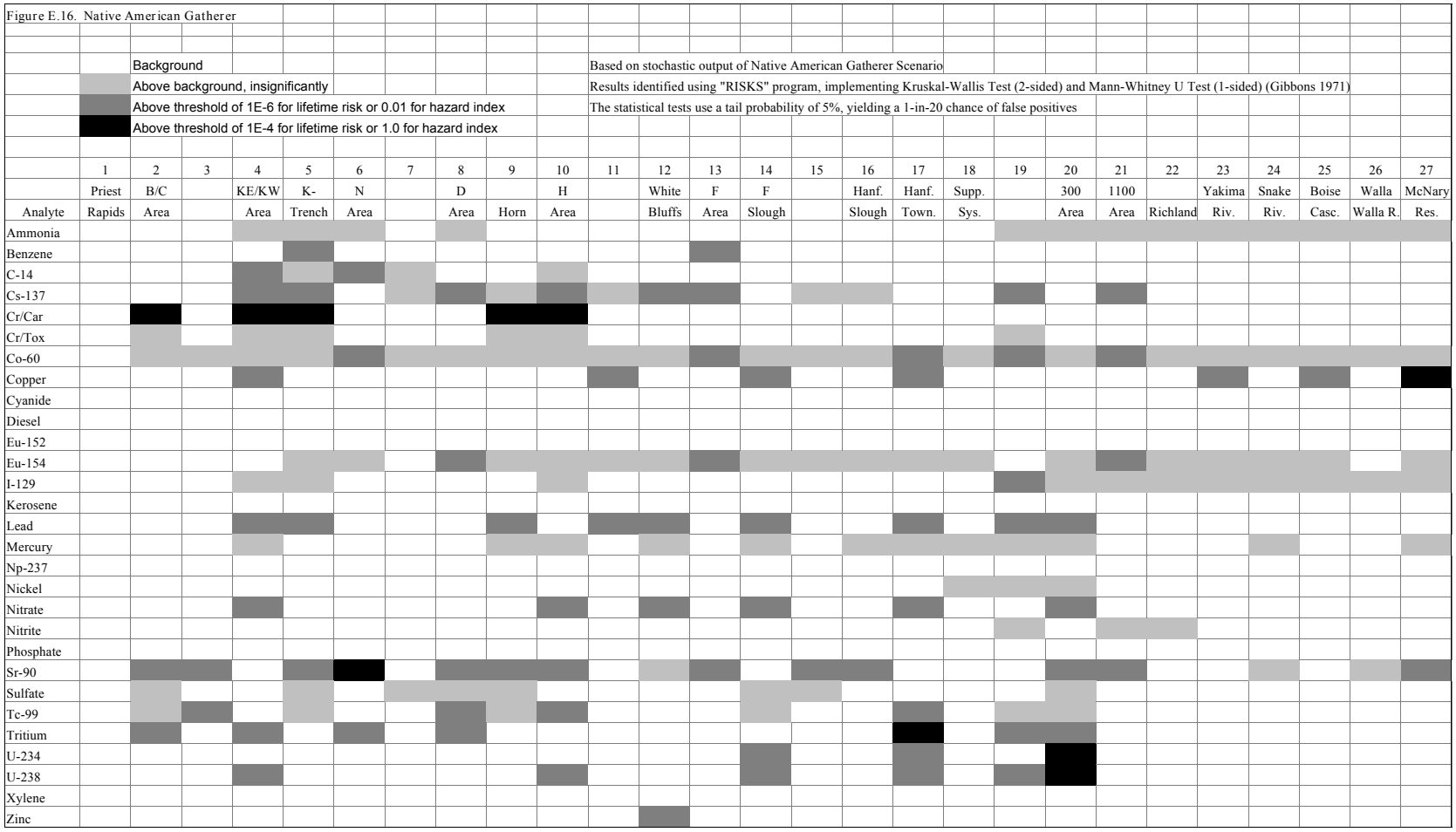


Figure E.17. Statistical Evaluation of the Differences Between a Segment Not Affected by Hanford Site Operations and Downstream Segments Affected by Hanford Site Operations for the Resident Scenario

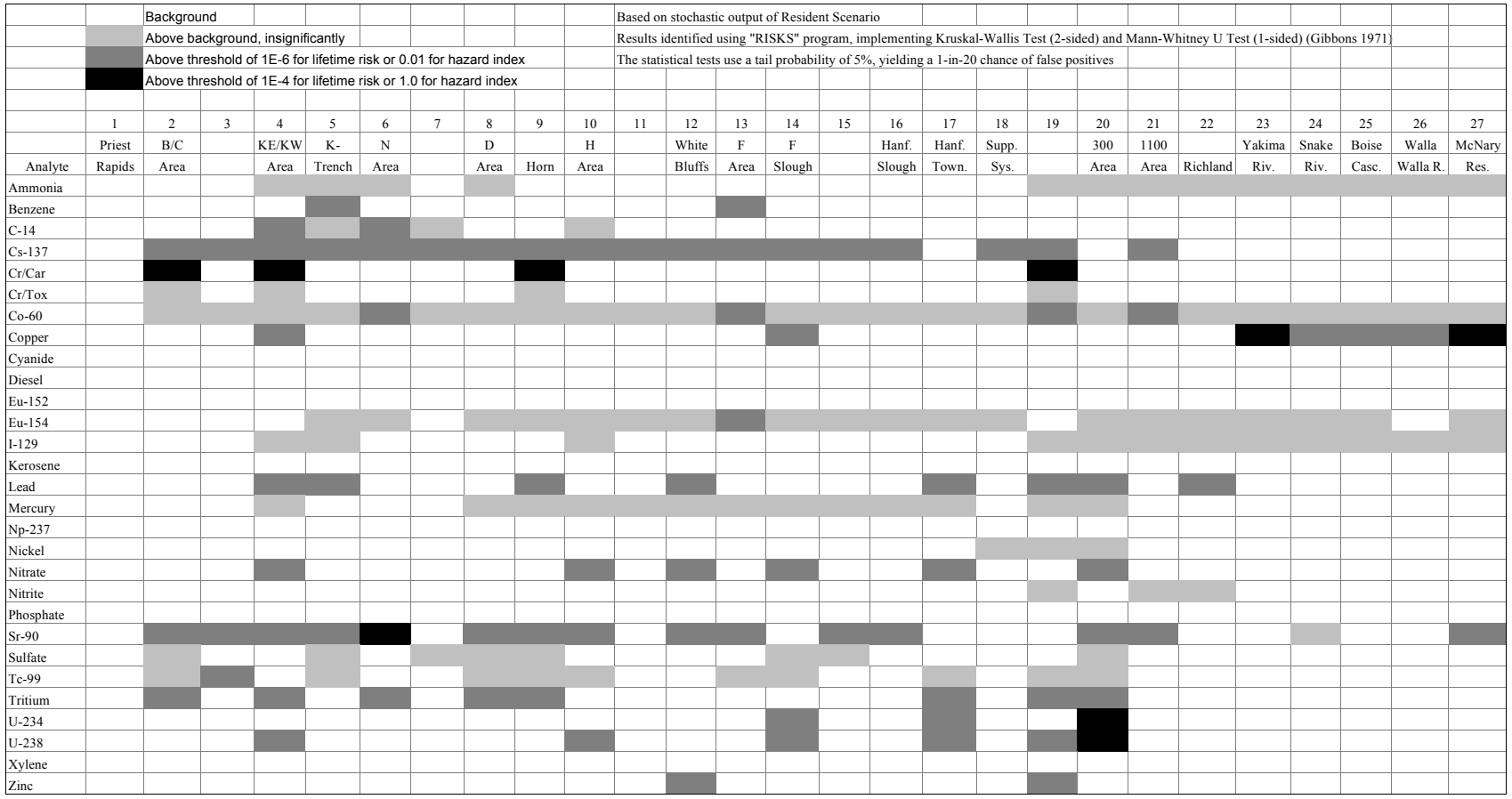
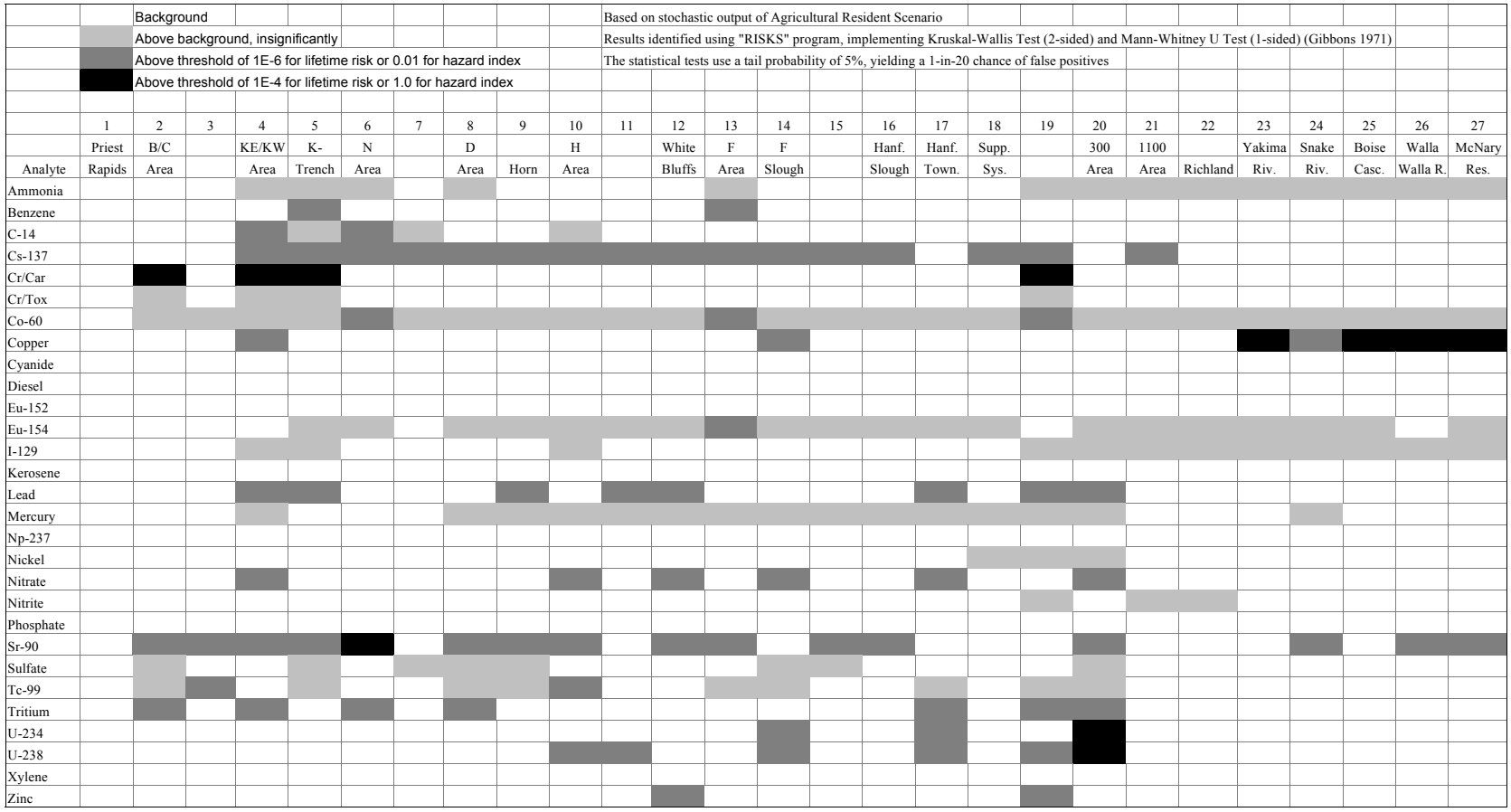

Background
Above background, insignificantly
Above threshold of 1E-6 for lifetime risk or 0.01 for hazard index
Above threshold of 1E-4 for lifetime risk or 1.0 for hazard index
Based on stochastic output of Resident Scenario
Results identified using "RISKS" program, implementing Kruskal-Wallis Test (2-sided) and Mann-Whitney U Test (1-sided) (Gibbons 1971)
The statistical tests use a tail probability of 5%, yielding a 1-in-20 chance of false positives
1 Priest Rapids
2 B/C Area
3
4 KE/KW Area
5 K- Trench
6 N Area
7
8 D Area
9 Horn
10 H Area
11
12 White Bluffs
13 F Area
14 F Slough
15
16 Hanf. Slough
17 Hanf. Town.
18 Supp. Sys.
19
20 300 Area
21 1100 Area
22 Richland
23 Yakima Riv.
24 Snake Riv.
25 Boise Casc.
26 Walla Walla R.
27 McNary Res.
Analyte
Ammonia
Benzene
C-14
Cs-137
Cr/Car
Cr/Tox
Co-60
Copper
Cyanide
Diesel
Eu-152
Eu-154
I-129
Kerosene
Lead
Mercury
Np-237
Nickel
Nitrate
Nitrite
Phosphate
Sr-90
Sulfate
Tc-99
Tritium
U-234
U-238
Xylene
Zinc

Figure E.18. Statistical Evaluation of the Differences Between a Segment Not Affected by Hanford Site Operations and Downstream Segments Affected by Hanford Site Operations for the Agricultural Resident Scenario


Background
Above background, insignificantly
Above threshold of 1E-6 for lifetime risk or 0.01 for hazard index
Above threshold of 1E-4 for lifetime risk or 1.0 for hazard index
Based on stochastic output of Agricultural Resident Scenario
Results identified using "RISKS" program, implementing Kruskal-Wallis Test (2-sided) and Mann-Whitney U Test (1-sided) (Gibbons 1971)
The statistical tests use a tail probability of 5%, yielding a 1-in-20 chance of false positives
1 Priest Rapids
2 B/C Area
3
4 KE/KW Area
5 K- Trench
6 N Area
7
8 D Area
9 Horn
10 H Area
11
12 White Bluffs
13 F Area
14 F Slough
15
16 Hanf. Slough
17 Hanf. Town.
18 Supp. Sys.
19
20 300 Area
21 1100 Area
22 Richland
23 Yakima Riv.
24 Snake Riv.
25 Boise Casc.
26 Walla Walla R.
27 McNary Res.
Ammonia
Benzene
C-14
Cs-137
Cr/Car
Cr/Tox
Co-60
Copper
Cyanide
Diesel
Eu-152
Eu-154
I-129
Kerosene
Lead
Mercury
Np-237
Nickel
Nitrate
Nitrite
Phosphate
Sr-90
Sulfate
Tc-99
Tritium
U-234
U-238
Xylene
Zinc

requirements, development specifications, development testing, and user's manual are available in the project records. An executable copy of the RISKS code is available on diskette with this report.

The RISKS code used as input the output of the HUMAN code described earlier in this appendix. However, these files are so large as to make their distribution impossible. They may be reproduced using the HUMAN code and the input files provided. The input files used to make the calculations reported in Section 5.2 are provided on diskette. A summary of the results of the downstream/upstream comparisons is provided in the Microsoft Excel file (updown.xls).

The contents of the diskette are:

Filename:	File description
riskcode.exe	Compressed, self-extracting, executable RISKS code
riskkey.exe	Eleven compressed, self-extracting, input files used to control the RISKS code for each scenario
riskrpt.exe	Eleven compressed, self-extracting, output files containing the results of the downstream/upstream comparison calculations
updown.xls	EXCEL 5.0 file of the numerical results of the RISKS calculations as well as the graphical displays of those results (Figures 5.5-5.32) for each contaminant for the Ranger and Native American Subsistence Resident scenarios

Scenario Additivity

The scenarios presented in Section 5.1 and evaluated in Section 5.2 do not address all possible activities that could occur at Hanford. The scenarios were selected to provide a broad range of information, not to specify actual risk to real individuals. Generally speaking, the several residential scenarios should cover most foreseeable exposures. However, for those interested in compound lifestyles, such as might occur with a resident of the downstream City of Richland who is also an avid recreational visitor, a simplistic approximation is provided to allow additional evaluations.

The process of creating a compound scenario involves selecting the base scenario (that which forms the basic lifestyle of the individual) and adding to it a fraction or multiple of the additional scenario. The river segments applicable for each scenario need also to be defined.

For example, consider the hypothetical case of the risk from radionuclides to a near-river resident of the City of Richland (Resident Scenario, Segment 21) who occasionally visits the Wahluke Slope Wildlife Refuge Area (Segment 13) for recreational purposes. The median estimate for the lifetime risk from radionuclides to the Richland resident can be found in the radionuclides portion of Figure E.8 to be about 4.4×10^{-4}. The median lifetime risk to a casual visitor to the Wahluke Slope recreation area in the vicinity of F-Reactor (Segment 13) is found in the radionuclides portion of Figure E.4 to be about 1×10^{-5}. The joint risk is the sum of these two values, about 4.5×10^{-4}. The additional activities that the individual enjoys on the Hanford Site add about 2 percent to her/his lifetime risk. The simple addition works because the

time spent on site is so small in the Casual Recreational Visitor Scenario that adjustments to the residential portion of the scenario are not significant.

For a more complex example, consider the hypothetical case of the heavy metal risk (as measured using the hazard index) to a traditional Native American subsistence resident who might permanently live north of the 300 Area (Segment 19) but regularly fishes near the influx of the Yakima River at Columbia Point (Segment 22). In this case, the underlying assumption of the Native American Subsistence Resident Scenario is 365 days/year at Segment 19, and 150 days/year at Segment 22. These fractions need to be adjusted to make a reasonable total number of days per year. If we assume that the individual fishes 75 days/year, then the total risk from the Native American Subsistence Resident Scenario can be reduced by a factor of (365-75)/365, and the total risk from the Native American Hunter/Fisher Scenario can be reduced by a factor of (150-75)/150. The hazard index in Segment 19, assuming full-time occupancy, for the Native American Subsistence Resident Scenario is found in the toxic chemical portion of Figure 5.6 to be about 4.3. The hazard index in Segment 22 for 100 percent of the Hunter/Fisher scenario is found in the toxic chemical portion of Figure E.6 to be about 2.7. Thus, the overall hazard index for this combined lifestyle would be

$$(365\text{-}75)/365 * 4.3 + (150\text{-}75)/150 * 2.7 = 4.77$$

There is very little overall change in the average hazard index for the subsistence resident achieved by combining these two activities in this way. The net increase results because, while ingestion of foods from Segment 19 is assumed to be reduced, they are increased by foods caught by the individual fishing at Segment 22. Note, too, that the bulk of the overall hazard index results from Segments 19 and 22 are caused by the intake of copper and lead, which are not significantly above background. This level of detail can be found by decompressing the file, nasubs_d.dtl, from the diskette of results (compressed in the det_dtl.exe file) and viewing it with a text editor.

Other combinations of scenarios can be evaluated in a similar fashion. Those wishing more detail are advised to adapt one of the input files provided and run the HUMAN code.